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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Lubrication of Glass Making Machinery

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LUBRICATION

A TECHNICAL PUBLICATION DEVOTED TO THE SELECTION AND USE OF LUBRICANTS

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Lubrication of Glass Making Machinery

CHEMISTRY and medicine have been helped in their progress to their present day standards by the ingenuity of the mechanical engineer in the glass industry and his cooperative research in developing high temperature-resisting utensils. The petroleum industry also has gained, for glass of the most intricate shapes and most accurate composition is essential to the study of petroleum gases and liquids and their chemical properties. In turn, however, the glass industry is dependent upon the petroleum industry for lubricants capable of functioning under the exacting conditions which prevail in the handling of the molten or plastic product as well as the finished product.

MANUFACTURE and formation of glass by machinery has had much to do with furthering its practicable application to modern science and home life.

Today, the glass plant handles its products mechanically from start to finish. This has enabled division of the industry into four broad classifications, viz:

(1) Bottle making, wherein compressed air is used for blowing purposes — a distinct improvement over the hand-blowing methods of only a generation ago.

(2) Window glass manufacture, where the glass is drawn directly from the furnace in flat sheets.

(3) The manufacture of plate glass, which is accomplished by drawing the molten product directly from the furnace to the lehr, from whence it goes to the grinding and polishing machine.

(4) Pressing Operations wherein glass articles are molded under pressure.

PREPARING THE CHARGE

Glass making starts with the furnace charge. This obviously is the controlling factor as to manufacture of the desired type of glass. The most common ingredients in a furnace charge include silica or sand, soda-ash, which is also known as sodium carbonate, potash, lime, borax and lead or some other metal.

Sand normally constitutes from fifty per cent to seventy-five per cent of the charge. Soda ash or potash forms the flux; the former is used when low melting point and economy of manufacture is desired. Potash in turn is preferable where a glass of high brilliancy is to be made. The necessary hardness is obtained by using lime (calcium carbonate) which also facilitates melting and refining. Borax imparts a low coefficient of expansion to the finished product, and lead in the form of litharge or red lead renders the product brilliant. Other metals such as zinc, aluminum, arsenic, tin, barium or antimony may also be used where glass of special qualifications is desired.

These products must all be carefully stored prior to usage. Overhead bins are advantageous for they enable feeding of each part of a charge in measured quantity directly to a mechanical mixer. A small amount of crushed scrap glass or "cullet" is often added to the charge. After thorough mixing the charge is carried by chute or conveyor to the charging end of the furnace.

The charge is heated to the melting temperature in some plants in a pot of one or two tons capacity or tank of from 50 to 500 tons capacity, the temperature being gradually brought up to from 2400 to nearly 2800 degrees Fahr. Melting in the tank type furnace is common practice in most glass plants. This enables a distinct economy of time and

fuel over batch melting in fire-clay pots.

The tank furnace affords storage for a continuous supply of molten glass of uniform mixture. Tank melting can be either intermittent or continuous. Intermittent tank melting for batch handling equipment does not operate continuously over more than a working day. In the continuous tank furnace, on the other hand, the charge is renewed at intervals to make up for the material drawn off. It is, therefore, built with a charging and working end. Melting and firing are carried out in the charging end, the charge flowing therefrom through a restricted "throat", into the working end where the molten glass is drawn off.

BOTTLE MAKING MACHINERY

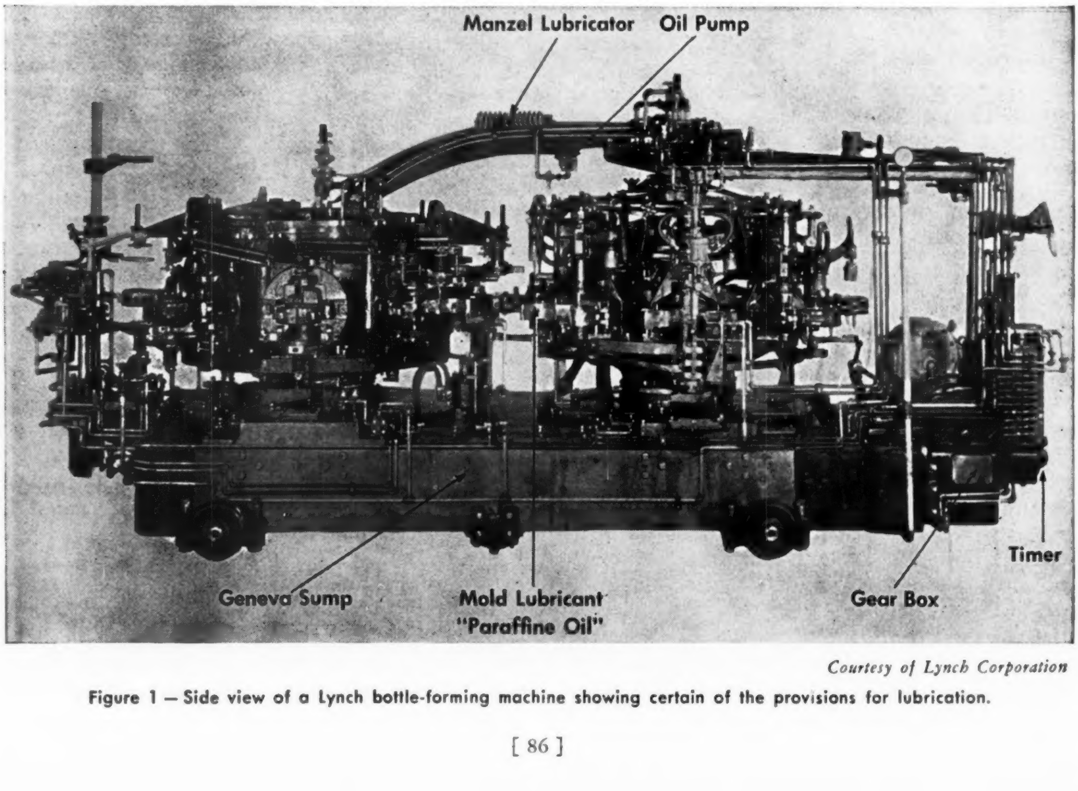
Cosmetics and beverages have had a decided influence upon bottle design and production in the glass bottle trade. So much so that modern bottle making has developed into a wholly mechanical process, whereby glass is blown by compressed air on specially designed machines. In fact, hand blowing is done now mainly for industrial purposes being confined to specialties and intricate chemical and research laboratory equipment.

The glass bottle phase of the industry produces a considerable percentage of the total glass manufactured in the U. S. The necessity for machinery capable of blowing up to a hundred or more bottles per minute can therefore be readily appreciated. The machine made bottle is uniform in finish, weight, capacity and appearance, and lends itself admirably to automatic filling and the use of sealing caps or screw-on tops.

Bottle making is classified as automatic or semiautomatic according to the type of machinery employed. The essential difference is in the manner of filling the molds and the transference of the bottle blanks from the preliminary to the finishing or blowing molds. The automatic machine eliminates the manual labor which is required by the semiautomatic machine for these two operations.

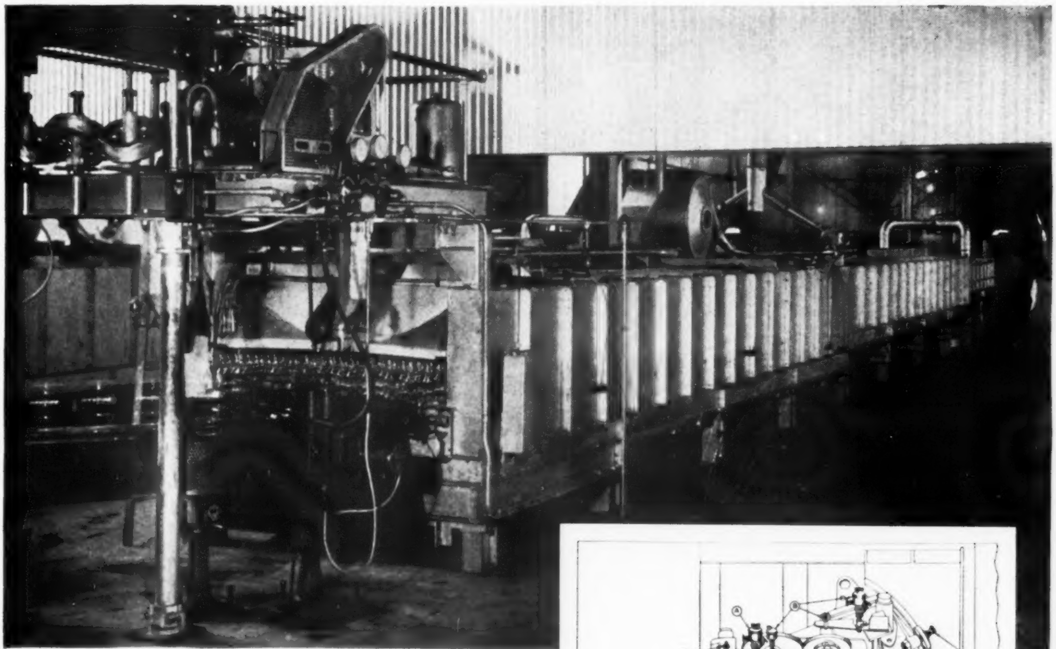
The transition in the manufacture of glass bottles from hand operations, to the semi-automatic machine where glass was gathered by hand, and thence to the full automatic forming machine has been distinctly interesting. The full automatic method came into usage with the development of the automatic feeder, whereby accurately measured gobs of molten glass are cut off and delivered by gravity to the molds. With this device a forehearth is used for temperature control.

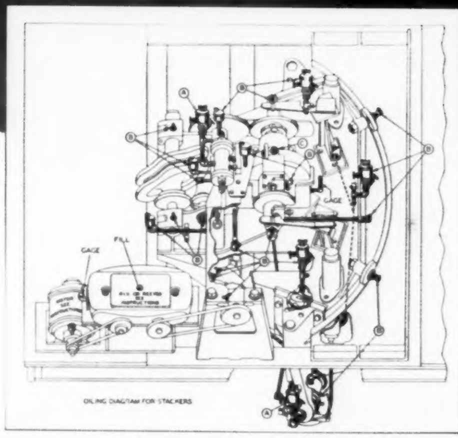
Molten glass is also handled by vacuum. In this procedure the working end of the melting furnace can be designed as a revolving tank driven by electric motor power through reduction gearing. This rotary motion of the molten product facilitates skimming so that a fresh surface is continually presented for suction.



Courtesy of Lynch Corporation

Figure 1 — Side view of a Lynch bottle-forming machine showing certain of the provisions for lubrication.





Courtesy of Hartford-Empire Company

Figure 2 — Typical installation of a Hartford-Empire "I S" conveyor, ware spotter, stacker and annealing lehr. At right is shown the lubrication diagram for the stacker.

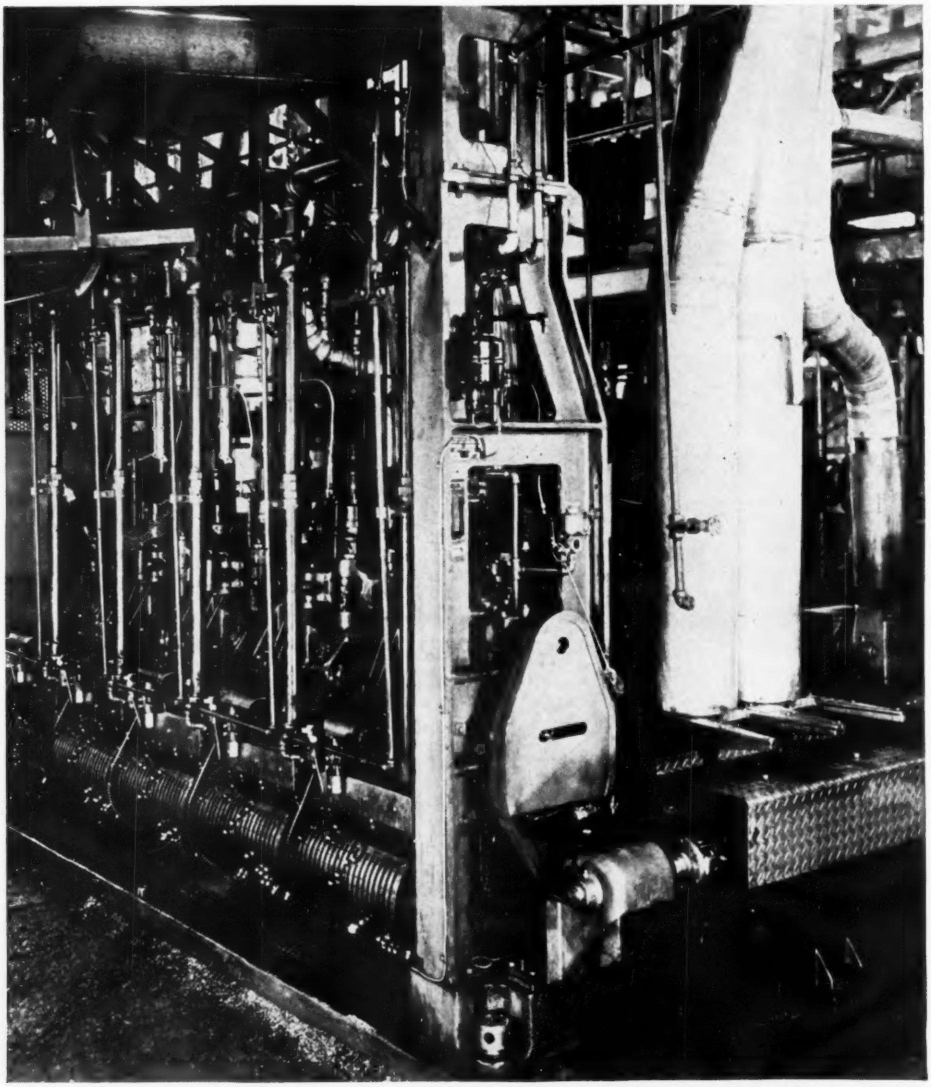
Dual Table Operation

The dual-table automatic and semi-automatic bottle machines also rotate. There two circular geared tables are involved, each carrying in symmetrical arrangement the same number of split molds which automatically open and close at regular intervals as the tables rotate. The molds on the first table receive the molten glass or so-called bottle "blanks" by hand or mechanical charging, and are usually designed for molding bottom-upward. As the table rotates a pneumatic plunger periodically functions to seal the top of each mold. At the same time a pneumatic piston ascends through the base of the mold to form the neck of the bottle. Following these formative processes, as the table rotates further the embryo bottle is given a preliminary blow with compressed air. At the next stage of rotation each mold is successively opened automatically, the blank removed, inverted and inserted in a corresponding finishing mold on the companion table. Both tables then move through another similar arc, the respective molds on each closing automatically. After closure the bottles are blown to final shape by compressed air. Fan air is also blown onto the outside of the molds for cooling. The bottles are ready for annealing in the lehr when discharged from these finishing molds.

The Single Table Machine

In the manufacture of bottles on a single table type of revolving machine, the blank molds are carried on fixed arms, the finishing molds being held by pivoted arms located symmetrically below the blank molds. As the machine rotates the blank molds may either pass directly over the molten glass in the furnace, the charge of glass being drawn up into each by applying a partial vacuum to the molds; or the automatic feeder may be used to deliver the gobs of glass. After the blank is gathered, a pivoted cutter turns it off even with the bottom of the mold and a plunger rises to form a small cavity, following which the "blank" is given a partial blow with compressed air. A slider is then passed over the top to give an even surface.

The "blank" is now ready for the finishing mold, so at this stage of operations each blank mold opens successively to deliver its contents to



Courtesy of Hartford-Empire Company

Figure 3 — Rear view, of a Hartford-Empire 5 section "I S" machine, showing timing drums; delivery system and cooling air piping.

its companion finishing mold, which is automatically brought into position by its carrier. Final blowing is then carried out while the finishing mold presses the exterior of the bottle into a uniform surface. The bottle is then automatically released onto a conveyor for transference to the lehr. The molds must be swabbed periodically to prevent sticking of the bottles. This machine can handle two or more bottles at a time when smaller sizes are to be made.

The Individual Section "I S" Process

The individual section glass forming process is based on the use of identical individual sections comprising a blank mold with its companion blow mold. There is no rotating table; the machine is laid out on the straight line principle. Two, four, five, eight or ten section units can be built into one assembly for normal production according to the size of the container to be made. This process can be used for a wide range of production from fractional ounce ware to gallon size containers. Compressed air at 30 p.s.i. gauge is used in this process.

The mold charge is fed to the blank (parison) mold of each section by the delivery system. The parison is formed upside down and is then transferred to the blow mold by means of the neck ring mechanism which immediately returns to the blow

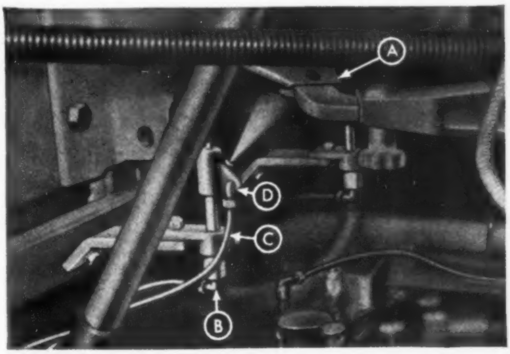
mold. Finished ware is blown in the blow mold while the next parison is formed. To aid in high speed production, a unique take-out and conveying system is provided. The conveyor may project either to the right or to the left, and may deliver either directly to a stacker or to a secondary conveyor. A feeder motor drives the "IS" control drum, from which all functions are pneumatically operated, except the mechanically driven conveyor.

Bottle Machine Lubrication

The manner in which the various working mechanisms in the vacuum type bottle machine must function in close proximity to the furnace and heated product involves one of the most exacting lubricating problems in the industry due to the possibility of carbon residue accumulation on certain of these parts, if the oil is not selected specifically for its low Conradson carbon content. Such deposits can be very objectionable if they are drawn through the headers by the suction effect in gathering the glass, and accumulated in the receiver which is usually located between the bottle machine and the intake side of the vacuum pump. If this residue passes into the vacuum pump cylinder, frequent cleaning of the valves, cylinder head, exhaust pipe and receiver will be necessary.

The most suitable oil for this type of service is a relatively light bodied straight mineral product, especially low in Conradson carbon residue content. In general it is handled automatically by a pressure lubricating system to the entire operating mechanism of the machine.

A step bearing which normally is designed to operate in a bath of oil carries the main spindle in a vacuum machine. Flood lubrication of this nature permits of the use of the same oil as suggested for the other working mechanisms of the machine. The guide bearing which carries the upper end of this spindle, however, is often grease lubricated by pressure gun or compression grease cup with a medium bodied cup grease or fiber type grease.



Courtesy of Hartford-Empire Company

Figure 4 — Shear lubrication details for a Hartford single feeder. "A" is the shear blades; "C" line for soluble oil; "B" the air line and "D" the shear spray head.

The machine is driven by reduction gears, which are lubricated with a straight mineral gear lubricant of around 1000 seconds Saybolt viscosity at 210 degrees Fahr.

Lubrication of the dual machine is not so much of a problem provided a high grade gear lubricant similar to the above is used, and the bearings are kept supplied with a well refined straight mineral oil ranging in viscosity around 300 seconds Saybolt at 100 degrees Fahr.

MAKING WINDOW GLASS

Window glass — one of the most essential as well as the most comfortable product of the glassmaker's art also is made mechanically in the modern glass plant. The advantages include:

(a) More comfortable operating conditions

(b) More uniform production schedules

(c) Lower cost

The modern procedure involves continuous drawing of the glass directly from the furnace to the lehrs in the form of a flat sheet. To some extent the principles of operation are akin to the modern method of drawing plate glass. This latter, however, is always drawn horizontally, whereas window or fire-finished glass may be drawn either horizontally or vertically. Both methods result in marked improvement in operating economies and better lustre and surface uniformity of the finished product.

Quite naturally, development of these processes required careful study of furnace design and methods of mixing the charge, as well as the selection of the raw materials. Furnace operations must be continuous, commensurate with the rate of drawing. Uniformity and temperature control are highly important.

Drawing is carried out in the drawing chamber of the furnace canal. The ribbon of glass is drawn up and over rolls onto the approach table of a horizontal lehr, or vertically from the molten material through specially designed rolls and a vertical lehr wherein a gradual cooling of the glass takes place to eliminate the possibility of internal strains.

Starting the draw on a vertical machine requires the use of a metallic "bait". This is lowered into the molten glass in the drawing chamber of the furnace, where it "gathers" an adhering charge in a few seconds. By setting the machine in upward motion the "bait" is then raised with its adhering charge of glass. This ribbon, as it is drawn upward from the furnace, passes between successive sets of gear-driven rolls. The thickness of the glass is con-

trolled by the speed of drawing. After the ribbon has once been formed the "bait" can be cut loose, for the surfaces of the rolls furnish the necessary traction power to carry the glass upward through the lehr. Roll marking or scratching is prevented by building these rolls up carefully with selected and prepared asbestos surfacing.

Upon emerging from the lehr the sheet or ribbon of glass is ready for cutting into desired lengths for trimming and cleaning. This latter process involves the use of dip vats, usually containing muriatic acid, which effectively cleans the surface of the glass and increases resistance to staining. After a water wash the glass is dried; it is then ready for final cutting to shipping sizes.

Continuous Horizontal Drawing

In this process a continuous sheet of glass is drawn directly from the melting furnace over suitable rolls, and thence through a long horizontal lehr. The starting "bait" in this process consists of an iron bar several feet long which is lowered horizontally into the molten glass each time a charge is to be gathered. This bar with its gather of plastic product is then raised for a few feet to enable drawing of the charge over a roller, after which the charge is pulled horizontally by the "bait" into the lehr which may be upward of 200 feet long. The speed at which the sheet is drawn controls the thickness. After the sheet has been drawn to the desired length the "bait" is cut away. From the lehr the sheet passes to the cleaning and cutting departments as outlined above.

Lubricating Window Glass Machinery

Lubrication of machinery incident to the manufacture of sheet or window glass involves the mixing equipment carrying devices, motors and auxiliaries, such as blowers, compressors and gas producers. The latter will present the normal lubrication requirement encountered in power plant operation. Lubrication of the actual glass-making equipment, however, will involve a heat condition which must always be considered when selecting the lubricants.

The hoisting, carrying and elevator equipment employed in the window glass plant is, in general, built up of an assembly of gears, bearings and wire rope. In the analysis of lubricating requirements of gearing the manner of housing should be investigated. An enclosed spur or bevel gear set can normally be lubricated by a lower viscosity product than where the installation is exposed. As a rule a straight mineral lubricant of from 200 to 500 seconds Saybolt Universal viscosity at 210 degrees Fahr., will function satisfactorily in a bath-lubricated housed installation. On exposed gears, however, in the interest of lubricant economy and adhesion of the product to the gear teeth, the viscosity should be raised to the neighborhood of 1000 seconds Saybolt. Lubricants within the above viscosity ranges also can be used for wire rope protection, according to operating temperatures. Worm gears require a specially prepared gear lubricant within a 150 to 200 seconds Saybolt Universal viscosity at 210 degrees Fahr. range. Mild E.P. properties as imparted by lead soaps are desirable to adequately protect the worm and gear teeth.

A well refined straight mineral oil of from 200 to 300 seconds viscosity Saybolt at 100 degrees Fahr. is required for the bearings. This same oil can also be applied to ring-oiled electric motor bearings. Where grease is called for, a medium consistency product capable of handling in a pressure gun and withstanding comparatively high temperatures is advisable.

When sheet glass is drawn directly from the melting furnace difficulty in the lubrication of the roll bearings may result due to the high temperatures which prevail. The heat may cause carbon accumulation to interfere with oil circulation through bearing clearance spaces, unless a specially refined lubricant is used. For this reason a straight mineral type of steam cylinder oil is preferred, prepared from selected crude. High flash and fire points, low Conradson carbon residue, and minimum vaporization tendency are required properties.

PLATE GLASS

Continuous drawing of plate glass has been one of the outstanding production developments in the modern glass industry.

In the plate glass plant today raw materials are handled entirely mechanically by means of bucket, flight, or belt conveyors. Mixing also is entirely automatic, accurately weighed amounts of each ingredient being drawn from storage bins to a mechanical mixer very much like a concrete mixer. After the contents of the mixer have been thoroughly combined, they are drawn to a conveyor mechanism which carries the material directly to the charging end of the furnace, a sufficient amount being admitted periodically to make up for the molten glass which is drawn off at the pouring end.

In continuous drawing the molten glass flows over a lip to a set of rolls which regulate the thickness of the sheet along with the speed of drawing. From here the sheet passes over other rolls to a horizontal lehr, wherein gradual cooling is brought about for the purpose of strengthening and tempering the product and making it as resistant as possible to breakage. As it emerges from the cool end of the lehr the sheet is cut into sections about 10 feet long. At this stage of operations the glass is comparatively opaque. It must therefore, be ground and polished to bring about perfect transparency and smoothness of surface.

Figure 5 — In the manufacture of plate glass by the continuous process the batch is automatically injected into the furnaces. After "Cooking" the molten mass is ejected by gravity at the other end of the furnace through steel, water-cooled, forming rolls.

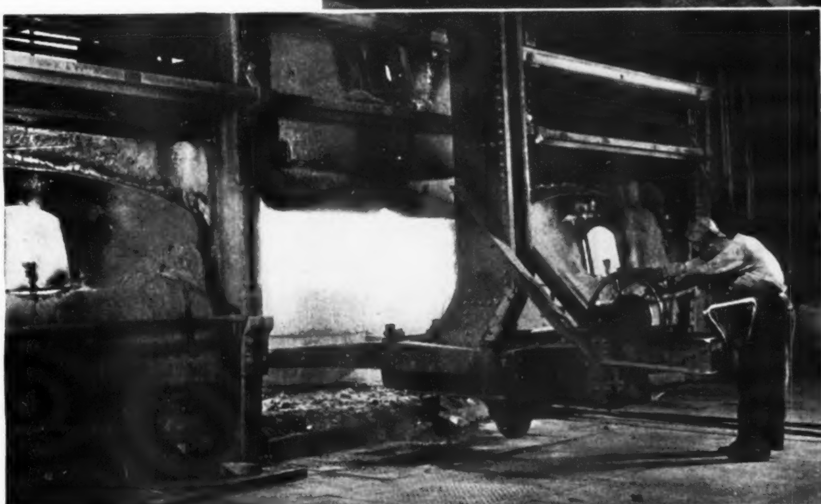


Figure 6—Pot-casting; a process still used for making smaller batches of special glasses — involves melting in special pots, and then pouring between the forming rolls.

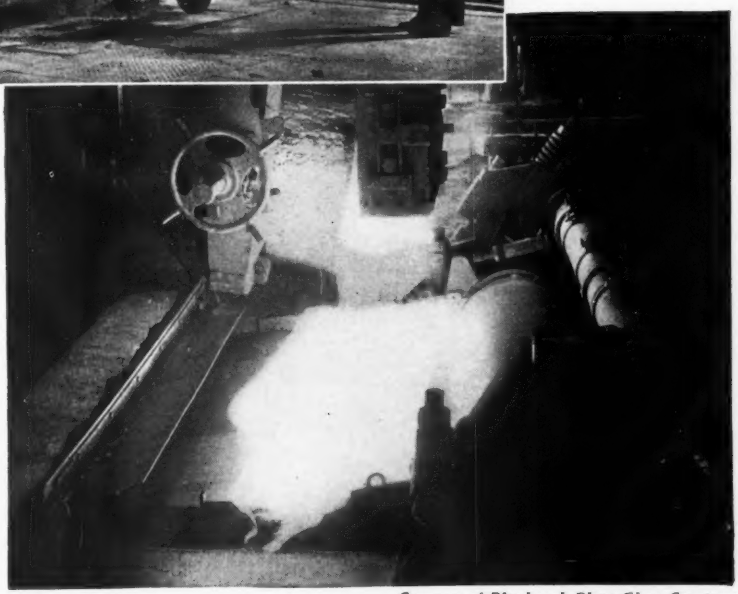


Figure 7 — Showing the forming rolls in action.

Courtesy of Pittsburgh Plate Glass Company

Grinding and Polishing

Grinding and polishing operations, also are continuous. The procedure is to place the plates on cars which carry them at a slow rate of speed beneath a series of rotating grinding and polishing elements. At the grinding end of the process, sand and then emery are used in conjunction with water to bring about preliminary finish; first one side being treated, and then the other. In this operation, the thickness of the plate is reduced about 50 per cent. To expedite this work each plate must, of course, be firmly fastened to the table, by pegging with wooden blocks and embedding it in plaster-of-paris to give as perfect continuity of surface as possible.

After grinding the surfaces are ready for polishing. In this operation the abrasive is rouge mixed with water. This is worked over the surface of the glass by felt runners attached to rotating brackets driven from above. A considerable number of these polishing elements are required at both the grinding and finishing ends of the machine. As the plates of glass move slowly underneath their actual contact portions, the comparatively high speed at which these latter are rotated works the surfaces smoother and smoother until at the end of the process the plates, after having been so treated on both sides, are ready for washing, cutting and inspection.

Lubrication in the Plate Glass Plant

Continuous drawing of plate glass has entirely eliminated the step bearing which used to be oftentimes a potential source of difficulty on the rotating type of plate glass polishing table. In the modern plant the chief problem involves selection of high temperature-resisting lubricants for use on machinery at the pouring end of the furnace and for the bearings, gears, and chains adjacent to the warmest part of the lehr. Elsewhere lubrication is very much the same as in any normal conveying operation.

In the grinding and polishing room, in turn, there are the bearings of the motors which drive the grinding and polishing elements, the reduction gears, and the guide bearings of the main shaft which extends from each driving unit down to the frame which carries the runners. It is not necessary in the glass industry to give much consideration to discoloration or contamination of the product after it has solidified and passed from the cool end of the lehr. Costly means for preventing leakage of lubricant from bearings or gear housings are often therefore not justified, although in the interest of lubrication economy all such housings should be as tight as possible. Chain connections, however, are frequently run exposed, particularly those which are installed on the roll drive mechanism of the lehrs.

The guide bearings of the grinding and polishing mechanisms carry but little load and, therefore, they can normally be lubricated with a well refined engine or machine oil of from 300 to 500 viscosity. This same oil can also be used on the bearings of the driving gear shaft and the driving motors where the latter are designed for oil lubrication.

Gearing incident to the operation of these same mechanisms can be best protected by means of a specially prepared gear lubricant of around 1000 seconds Saybolt viscosity at 210 degrees Fahr. Consistency and adhesiveness must be given equal consideration for resistance to centrifugal force with minimum development of internal friction is highly essential. On some of the lighter gears which serve to transmit rotary motion provision for bath or automatic circulation of lubricant will permit the use of a more fluid product, ranging in viscosity from 150 to 200 seconds Saybolt Universal at 210 degrees Fahr. On the other hand, when exposed, these gears will function best on a heavier, more adhesive product, which will stick tenaciously to the teeth.

Other equipment in the plate glass plant requiring lubrication will include the traveling mechanism of the lehrs, and the various overhead cranes essential to handling the plates of glass to storage. Lubrication of the moving parts on such machinery will normally present no particular difficulty, and it can be broadly classified in two distinct groups involving gears and bearings. For general bearing lubrication a well refined machine oil of from 200 to 300 seconds Saybolt viscosity will give adequate protection. For the gears it is well to use lubricants similar to those suggested for the polishing and grinding machine drives, the viscosity being chosen according to the manner of housing, the load and degree of protection required.

PRESSING OPERATIONS

The manufacture of pressed glass specialties and chemical apparatus is of interest chiefly from the viewpoint of the unique design. Lubrication is not difficult by reason of the type of machinery and methods employed. Jars, wide-mouthed bottles, and block mold ware, such as tumblers and other table utensils, are made today by molding molten glass under internal and external pressure. Pressing is carried out on a specially constructed machine, involving a revolving table which carries the molds. The heated glass after charging is forced to the shape of the molds by means of pneumatically operated pistons. This functions oftentimes in conjunction with a direct-acting press or toggle mechanism. The latter type of control is often preferred when pressing high grade ware, in the opinion that a more even distribution of load prevails.

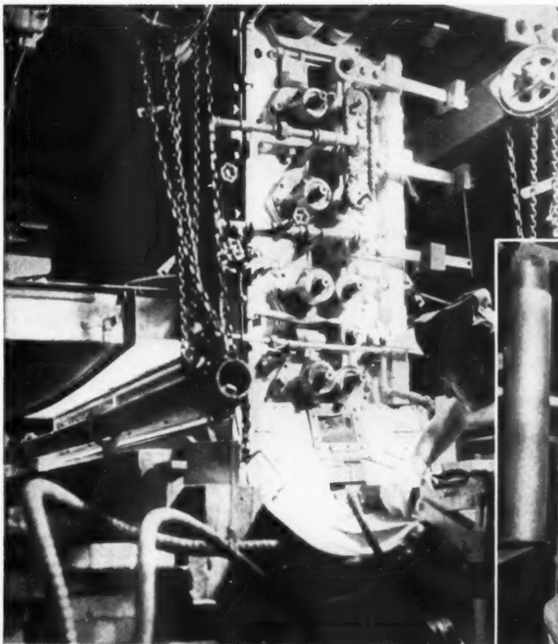
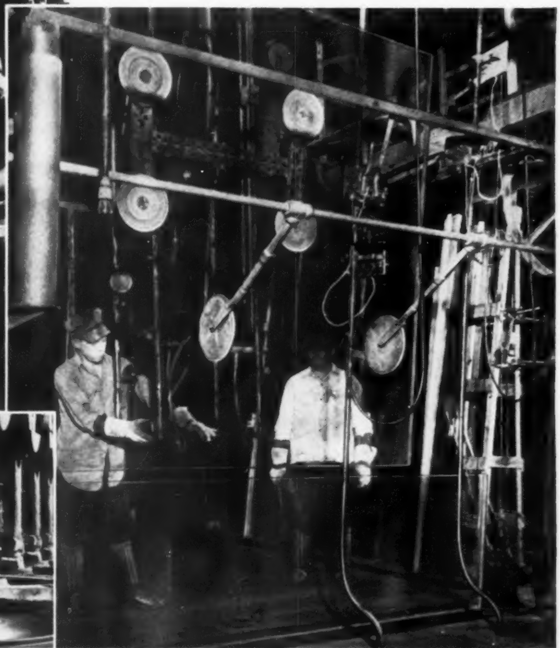


Figure 8 (Left) — Drawing window glass, to enable the "bait" to gather and draw the glass vertically up to the rolls.

Figure 9 (Below) — Cutting window glass to uniform size by an electrically charged mechanism.



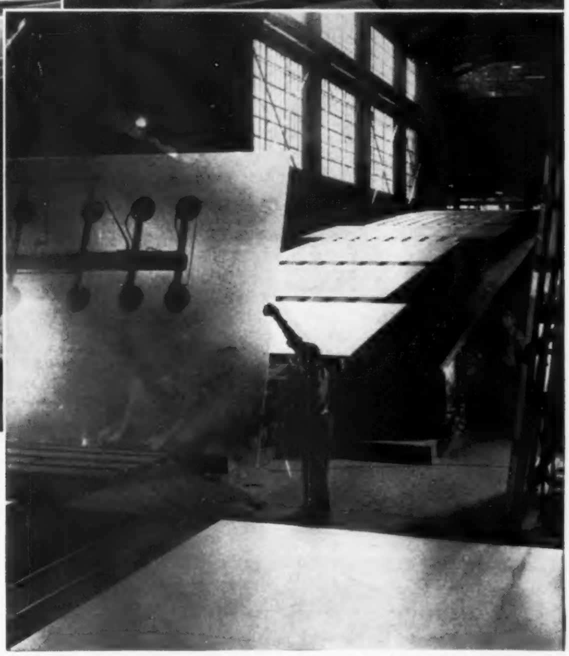


Figure 10 (Above) — Grinding and polishing glass plates under a battery of rotating discs.

Figure 11 (Right) — Conveying glass plates by suction cups after cutting, to either the grinding and polishing departments or to storage.

Courtesy of Pittsburgh Plate Glass Company

SPECIALTY MANUFACTURE

Glass specialties include electric light bulbs, automobile headlights, intricate vase ware, lighthouse lenses, and chemical glass ware equipment. In the manufacture of such products the process may involve blowing or pressing of glass. The delivery of glass from the melt to the final shaping operation may be by means of hand gathering of hot pasty glass or by mechanical means. Hand gathered hot glass is picked up by means of a tubular blow pipe for hollow blown ware and by means of a solid pontil rod for ware as pressed to shape.

For hand blown ware the gather of glass on the hollow pipe is shaped skillfully by the blower and then placed in a mold usually of two halves split along the vertical or blow pipe axis. The ware is blown to shape in the mold. Frequently the cast iron mold contains a pasted surface of baked linseed oil and carbon or cork dust which surface is wet alternately between blowing operations. The glass as blown to shape (the shape must be symmetrical to the vertical or blow pipe axis) is turned relative to the mold or mold rotated relative to the glass shape. This simulates an air blown finish on the ware without presence of mold seams.

For hand pressed ware the gather of soft pasty glass is cut from the pontil or punty rod in desired quantity by means of shears and dropped into the mold in the case of hand pressed ware. The presser then forces the plunger through the ring into the mold and forms the hot glass gather or gob into the mold cavity shape.

Automatic machine operations sometimes perform the same operations by mechanical means.

For pressing operations the hot glass is fed from an automatic gob feeder and cut off by shears and dropped into the press mold where the plunger again presses the glass to shape of the internal cavity of the closed mold, the press machine being synchronized to the speed of the feeding mechanism.

Many of the above specialty blown ware items are made from hot glass continuously flowed from an orifice. Tubing is such an example in which case the hollow blow pipe is replaced by a hollow member better suited for continuous pulling and blowing of tubing from the continuous stream of glass.

Some hollow articles such as lamps bulbs are also formed from a continuous stream of glass, the stream being reshaped and distributed in ribbon form over the blowing stations. The paste mold is then rotated relative to the glass shape.

Lubrication of Pressing Machinery

The working mechanisms on most glass pressing machinery are usually lubricated automatically, by pressure, bath, or splash distribution of the lubricants. On the wide-mouth bottle press the driving gears located in the base of the machine will usually run in a bath of oil. Certain types of these machines are also equipped with an oil pump, filter, and adjustable sight feed lubricators, to enable more or less completely automatic lubrication of the other working parts. Two distinct types of lubricants will be required on such machines —

(a) A straight mineral gear lubricant having a viscosity range of from 100 to 150 seconds Saybolt Universal at 210 degrees Fahr.,

(b) A well-refined machine oil of from 200 to 300 seconds Saybolt Universal viscosity at 100 degrees Fahr.

The revolving type of table is mounted on a ball step bearing. Lubrication of this bearing can be satisfactorily accomplished with either oil or grease according to the housing design. When oil-lubricated the bearing is virtually flooded with lubricant; under such conditions the oil also serves as a cooling medium to some extent. In the grease-lubricated bearing, however, no cooling is accomplished by the lubricant furthermore, the amount of lubricant in the bearing will be less than in the oiled design. Best practice dictates partial filling of a grease-lubricated ball bearing, to reduce the tendency towards channeling and overheating, through internal friction.

The air cylinders and other pertinent parts with which the air comes in contact on the modern glass press are lubricated by impregnating this air with oil as it enters the machine. To accomplish this an automatic sight feed lubricator is usually installed in the main air supply line. In this way oil can be fed drop by drop into the air stream, so that as it passes through the machine it will carry sufficient lubricant to serve the valve and cylinders, to cool, clean and lubricate the shear blades in the semi-automatic machine and to clean and lubricate the blank molds in both the automatic and semi-automatic machine. In addition, when certain of the rotating mechanisms are operated by air, the oil content will also lubricate these parts and help to prevent accumulation of crushed glass.

THE LEHR

The lehr plays an important part in glass making. It functions to combine time, speed and temperature in order to subject the glass to an annealing or gradual cooling treatment. This insures against the development of internal stresses, which would probably cause shrinking, cracking or complete disintegration at the least scratch or shock later on.

The horizontal lehr is usually an oven-like brick and steel plate housing of from 50 to 300 feet in length, according to the material to be handled, and of a height and width to conform to the type

of glass-ware produced. Extending longitudinally within, is installed a form of conveyor such that the product can be suitably carried thereon. This is electrically driven from without, through an arrangement of reduction gearing.

All lehr operations are now continuous, the conveyor being frequently of wire mesh which passes through the entire length of the lehr at constant speed. Bottle lehrs, for example, may have an enclosed tunnel up to 100 feet in length, from one-half to three hours may be required for passage of the ware depending on the thickness and dimensional characteristics.

Heating is done by gas, oil or electricity at the charging end of the lehr, to a temperature of from 800 degrees to 1200 degrees Fahr., dependent on the size and type of glass treated.

SPEED REDUCTION GEARS

The advantages of the enclosed type speed reducer have been definitely proved. Both constant speed and variable speed units are used. As the primary element in transmission of power to conveying equipment, the speed reducer is a dominating factor in efficient operation. Furthermore, inasmuch as its performance is contingent upon effective lubrication, adequate protection of gear teeth and bearings by lubricants suited to the operating conditions is absolutely essential.

In view of this fact, the most serious attention should be given to choice of products which will function best under the constructional requirements and be resistant to dust contamination.

Experience has proved that for the larger spur or herring-bone type of exposed or semi-enclosed reduction gear a straight mineral lubricant will give best protection. It should contain no filler such as rosin or talc, etc., it should not harden, separate, gum, dry, crack or disintegrate under exposure to varied temperature rises. A lubricant of this nature will possess natural tendency to follow the gear teeth, thus increasing economy to a marked extent by virtue of the decreased frequency of application that is required. This adhering ability will of itself guarantee longer life to the gears by effectively protecting the teeth against wear. According to prevailing loads the viscosity of such a lubricant should range from that of an extra heavy motor oil to a steam cylinder oil.

Manufacturers of worm reduction gears, on the other hand, prefer a compounded lubricant, of the nature of a steam cylinder oil, containing in the neighborhood of five percent of animal fat; or the newer type of non-corrosive lead soap lubricant. This product has the advantage in that it not only gives good protection to the gear teeth, but also is effective on the bearings.

Gear Housing an Adjunct to Effective Lubrication

Keeping gear sets enclosed in comparatively oil-tight and dust-tight housings is of paramount importance in the interests of effective lubrication and prevention of wear. One must appreciate that the most essential characteristics of a good gear lubricant are that it shall have a high degree of adhesiveness and a suitable body or viscosity, in order to resist the throwing-off effects of centrifugal force. These very characteristics, however, also render such a lubricant subject to rapid contamination by dust or dirt, if exposed to them.

Contamination of this nature is, of course, decidedly objectionable as it materially reduces the lubricating ability of a gear lubricant, converting it into more or less of an abrasive paste, according to the hardness and the extent of the foreign matter involved.

To prevent such contamination, gears, wherever possible, should be adequately protected by suitable casings. Furthermore, the fact that many gear installations will function more effectively and with less consumption of power if lubricated by a relatively fluid product, renders it all the more advisable to use oil-tight casings. Especially is this true in the case of worm and herringbone gear installations; for this reason such designs are usually enclosed in very carefully planned housings which not only prevent entry of foreign matter, but also any leakage of lubricant.

For reasons of economy or practicability, however, many spur, bevel and other type of gear drives cannot always be so tightly enclosed. Many operators of older machinery in the face of such conditions may even allow such gears to operate absolutely open.

Gears which operate exposed either entirely or in part, will require lubricants of heavier body or viscosity than those which are tightly encased. Such a product might range in viscosity from 500 to 10,000 Seconds Saybolt Universal at 210 degrees Fahr. This, of course, means that more power must be consumed in their operation for the reason that heavy lubricants impose an appreciable "drag" or braking action as the teeth pass in and out of mesh. Furthermore, the heavier the lubricant the greater will be the tendency for it to pick up and absorb dust, dirt and other abrasive solid matter.

Owing to the extent to which machinery and mechanism may vary, it can be appreciated that gear lubrication can very easily involve all manner of difficulties. Necessarily the lubricating engineer must deal with equipment as is stands, hence he must develop the best practices possible to meet and serve the conditions existing. To a certain extent recommendations are possible for alteration in housing design to enable gear and bearing pro-

tection against dust; or for the conservation, preservation, and reclamation of applied lubricants, etc.; but to be effective all this must actually be carried out by the mechanical organization of the plant, and it requires close attention and experimentation. Observation of the above remarks as to the lubricant itself, will be of aid to all concerned, and if selected to meet conditions and applied as advised, gear lubricating troubles will seldom be serious.

Where gears are not contained in an oil or dust-tight housing, weekly applications of lubricant are usually customary, although where the gears are entirely unguarded and dust is especially excessive, this period should be decreased somewhat. It must be remembered that a lighter grade of lubricant will last longer and yield better results under such conditions. The heavier grade that would be used under clean operation cannot be expected to maintain an efficient lubricating film under dirty conditions, due to its tendency to accumulate dust. In some cases, it may be advisable to resort to a very considerably lighter lubricant, than would normally be recommended.

Oil Level Important

It is essential to remember where gears are bath lubricated that the level of the oil must be carefully watched. This will be especially true where heavier lubricants are used, and where there may be a comparatively wide range of operating temperatures, for one must remember that the development of "drag" or excessive internal friction may become a decided factor in the matter of power consumption.

As a rule where gears are bath lubricated it will be well to carry the oil level at such a height as to insure dipping of the teeth of the lower element to the extent of two or three inches. Submergence of too much of the gear or pinion is not advisable and, as a general rule, unless comparatively fluid oils are used, it will not be necessary. The teeth will carry an adequate amount of oil up to those of the companion gear.

In the lubrication of gears in the glass industry as in the case of many other types of production machinery, it must be realized that the problem will involve more than the mere prevention of wear or noise. There will be a direct relation to continued operation.

In other words, whereas wear will eventually necessitate replacement, back of all this is the development of detrimental operating conditions which may not only impair the quality of the product but may also increase power consumption. It is surprising how much power can be wasted as a result of neglect and lack of appreciation of the fact that gears are quite as accurately designed as any other machine parts. As a result their lubrication is of equal importance.

In view of the comparatively heavy bodied character of the lubricants usually employed for such service, these facts must be appreciated and the oil level especially must be studied in order that it may be maintained at just the right point on all installations.

There is one thought, however, which must not be overlooked. With heavier gear lubricants it will be possible to run with a somewhat lower level than where more fluid products are used. It is for this reason that reduction gear units are usually equipped with an external gauge glass to enable the operator to observe at all times just what level he is carrying.

MATERIALS HANDLING METHODS

Handling of raw materials in the glass plant may be more or less of a manual operation where comparatively small volume is involved as in specialty or press operations, or it may involve an intricate assembly of bucket, screw and belt conveyors where bulk delivery is necessary as in the modern plate or window glass plant.

Equipment of this type must be rugged in construction to withstand hard usage, and yet of comparatively simple design.

There is considerable possibility of damage to bearings and other conveyor elements in the preliminary handling of the sand and other raw materials unless they are properly housed, for there will always be considerable dust present. For this reason, great care is observed to protect these parts in the modern plant and to maintain this protection in service with adequate lubrication which will both prevent wear and serve as a seal against entry of abrasive foreign matter. In this, we must consider the bearings which support the conveyor elements, and the gears or chains of the driving mechanism.

All of the above-mentioned types of conveyors are readily capable of handling considerable volumes of dry materials.

CONCLUSION

Lubrication of machinery used in the manufacture of glass is directly related to a precision operation, even though the machinery itself obviously is rugged and designed to operate under severe temperature, and very often, pressure conditions. The final product — glass — whatever its type or shape must be turned out to precise dimensions often bordering on the artistic. The machinery designed to produce these finished products, therefore, must function in a synchronized procedure — it is another phase of mass production which only can be assured by perfect coordination of the working parts. Effective lubrication assures this coordination.

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